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GEOGRAPHICAL RELIEF MAPS: THEIR USE AND MANUFACTURE.

BY

COSMOS MINDELEFF.

Geographical and topographical maps in relief have not attained the use which their advantages merit. This is due, not to any lack of appreciation of the system—for opinion on that point is practically unanimous—but to a variety of causes, prominent among which may be mentioned the high first cost of such work, and, in a lesser degree, a prevailing impression that any one can make a relief map. Such an impression invariably leads to disappointment, and the system is condemned when the fault lies only with the workmanship. A relief map is essentially a portrait, and we can no more expect good work from a novice in that line than in any other line of portraiture—sculpture or painting, for example. In either case the workman must have a definite and clear conception of the final result for which he strives; otherwise his work will be worthless. Another element which has had some bearing on the problem of the wider use of relief maps is a disposition on the part of those for whom they are usually made, generally scientific men, to look more closely after the manner of making than after the result—an apotheosis of method, as it were: not an uncommon failing in other branches of scientific work. None of these tendencies, however, seems insuperable.

Concerning the advantages of relief maps over other methods of picturing a section of country there is little difference of opinion. Contrary to the usual experience, on this point experts—that is to say, scientific men—and laymen are in full accord. In a letter received by the author from Prof. John Tyndall a short time before the latter's death, the great authority on physical geography said:

> From your photographs and photo-engravings a better idea of the general aspects of a country is to be obtained than from much reading.

This statement was made with reference to a series of sketch maps of the grand divisions of the earth, made for use in a text-book of geography for school use. A reproduction of one of the models—South America—is presented with this paper.

Mr. Charles D. Walcott, the present director of the United States

Geological Survey, entertains a high opinion of the value of such work. He writes as follows:

> This method of representing the country, if well done, is superior in its graphic effect to the best maps . . . Your models look like the country.

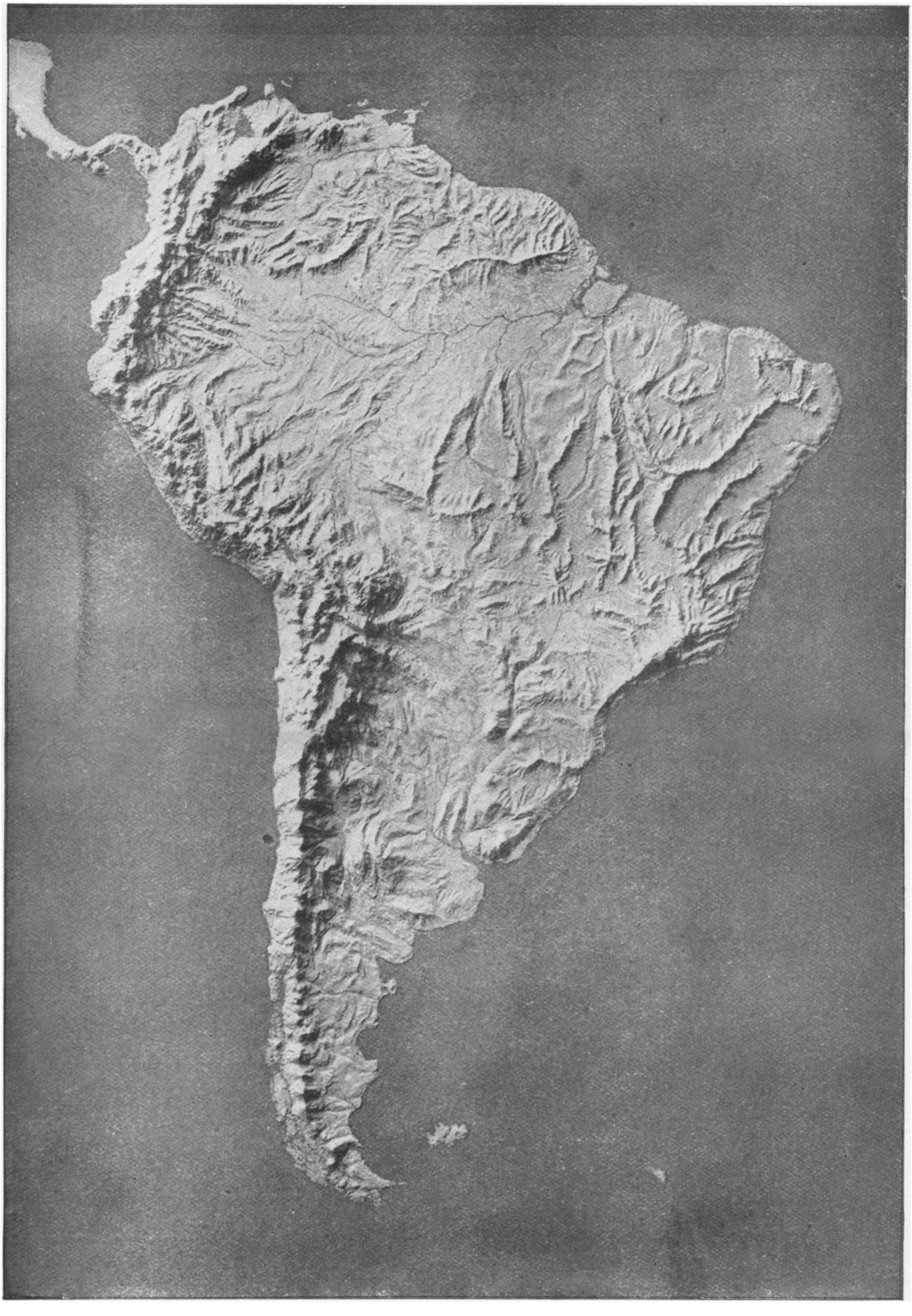
Major J. W. Powell, the former director of the United States Geological Survey, holds similar views, and during his administration of that bureau the largest collection of relief maps in this country, if not in the world, was accumulated. Mr. Henry Gannett, the chief geographer of the Survey, than whom no one is more familiar not only with relief maps but with all other methods of map-making, writes:

> I have made a critical examination of many, if not most, of the models prepared by you. Of the hundred or more such pieces of work that you have turned out I have only words of praise. Your representations of relief are, to my eye, the most expressive and lifelike of any such work that I have seen.

The list might be multiplied indefinitely, but the quotations above are sufficient to show that whatever objections are made to relief maps are applicable only to the results in specific cases and not to the system as a whole. In other words, success or failure is largely a matter of the personality of the author of the model.

For the purpose of conveying to an untechnical mind an accurate impression of a given section of country no other system can compare with the relief map, and where, as in certain law-suits, it is essential that persons not familiar with maps should have a thorough understanding of topographic details, only a well-made relief map can supply the need, since in no other way—except, perhaps, by personal inspection—can a jury obtain so complete a picture of locality. To the engineer and "promoter" who seek to exploit some great project the relief map affords a means of exhibiting a section of country, and of making clear conditions that otherwise could not be grasped by those who lack technical knowledge. They are of still more value to those who have such knowledge, for they give an impression of the whole, of "the altogether," as it were, which cannot be obtained in any other way, not even by a study of the ground, which must necessarily be taken piecemeal if the area is at all large. For this reason geologists find relief maps particularly valuable, and a large number of those now in existence have been made for the use of scientific men.

As an instance of the widely diverse use of relief maps a case may be mentioned where the area to be pictured was not much larger than an ordinary dwelling-room, and the topography was the most simple, the site being on the side of a gently sloping hill. An



RELIEF MAP OF SOUTH AMERICA.

From BUTLER'S COMPLETE GEOGRAPHY—*By permission of the publishers, Butler, Sheldon & Company.*

architect received a commission to improve a cemetery plot, but in working out his plans he encountered two difficulties which seemed insuperable. One was to select the exact thickness and height for a series of sloping walls which would bring them in harmony with the site, and the other was so to plan certain low structures, essential to the project, that they would not come into conflict with the cemetery regulations. He struggled with these problems for some time without making any progress until finally he decided to have a model made. A little relief map, hardly one foot square, removed all the difficulties. It was made to represent, first, the plot as it was; then it was graded and terraced and miniature representations of the walls were put in place, various thicknesses and slopes being tried one after another until the most satisfactory one was found, and finally the model showed the plot as it would be when the improvement was completed. The final model was submitted to the trustees of the cemetery as an exact picture of the plot as it would be, and was accepted by them, although the plans had been rejected previously. The architect then had merely to turn over to his draughtsmen the relief map, which was made very closely to scale, and the working drawings for the grading, stone-cutting and all the other details were made from it. At the same time objections which had been made by neighboring owners, who had believed that their plots would be badly affected by the proposed improvements, were withdrawn at once after an inspection of the little model.

Perhaps the most important use of relief maps is in educational work, although this is only a variation of the general problem, which is to convey an adequate and truthful representation of a section of country to those who have no knowledge of it. For this purpose the model is obviously superior to all other methods, for the simple reason that a relief map is an actual picture, while all other maps are more or less conventional representations, requiring more or less technical knowledge to understand them. An ideal system of teaching geography in schools by the aid of models would not be difficult to devise. Such teaching should proceed from the concrete to the abstract, and should begin with a thorough study of some small area convenient of access. Some well-known hill near-by, or part of one of the city parks, could be modelled on a large scale, and after the scholars became thoroughly familiar with the relief map they could be taken out and introduced to the region itself, if necessary comparing it with the model on the ground. Then the same region could be depicted on maps of various kinds and on different scales, a thorough study of which, in conjunction with the knowledge already acquired, would give the students a fair idea of what maps mean. Subsequently their mental horizon could be enlarged gradually by the use of models and maps of larger areas—first a county, then a state, afterwards the country as a whole and, finally, a continent. From his personal knowledge of parts the student would retain a lively interest in the whole, and the study of geography would change from its present "dry-as-dust" character to one of the most absorbing subjects in the curriculum. The plan of map-modelling in clay or putty, which is practised in some of the public schools, bears no resemblance to the system sketched above, since it lacks the essential feature of personal interest and personal knowledge of the region depicted.

The ability to read a map—that is, to obtain from a study of it an adequate mental conception of the country depicted—is much more rare than is commonly supposed. The writer has often made the statement that not one person in a thousand understands a contoured map, and he has never been contradicted. On the contrary, one of the best-known geographers in the country, who has supervised the making of hundreds of such maps, said on one occasion that one in ten thousand would be nearer the true figure. Yet with the modern tendency of map-making to the almost exclusive use of the contour system, such knowledge becomes more and more necessary every year. Any project of instruction, therefore, which promises to impart it is worth consideration.

Of the many methods of showing on a map the relief of a country but three have attained any vogue. These are: by hachures, by contours, and by relief maps. In the hachured system relief is shown by shading, more or less conventionalized, the effect being secured by small broken lines. In the majority of examples—indeed, in nine-tenths of the maps of this kind one sees—the system has degenerated into a purely conventional one, the graphic value of the method being lost sight of entirely, and the relief is shown merely by a few pen scratches, with little or no effort to differentiate the kinds of relief. Of such character are most of the maps seen in books as illustrations, of which the best that can be said is that they indicate that there are mountains in the country. In the best examples of hachured work—of which, perhaps, the Dufour maps of the Alps are the most perfect illustration—an attempt is made to represent the country as it would actually appear under given conditions of lighting; that is to say, with the light coming from a certain direction and at a predetermined angle. Obviously this method is an approximation to the relief map; but the result is not nearly so satisfactory, since its tendency is to exaggerate the minor elements of the relief at the expense of the main features. Moreover, it substitutes an artificial for a natural scale of shadows, and in practice there is no way to distinguish between a mountain 5,000 feet high and one of twice that height. Further, a mountain which rises 500 feet above a plain must be a less pronounced feature on such a map than one which has a height of 1,500, although the former might have an elevation of 12,000 feet above sea-level and the latter only 2,000. In other words, the principal characteristic of hachured work, in its best examples, is to bring out the details of the relief while sacrificing the main features. But the relief map brings out that detail in a much better way, and with a much more natural effect, while preserving the relative relief.

On the other hand, contoured maps sacrifice the graphic element almost entirely in order to exhibit the relative relief. The face of the country is shown by a series of continuous lines, each of which is equidistant, throughout its entire length, from sea-level or some assumed base. Looked at superficially, it would appear that any one should be able to understand a system so simple, for all that is necessary to determine whether one point is higher than another, and how much higher, is to look at the contours. As a matter of fact, however, the system is so purely a conventional one that even long training and much experience do not enable one to determine the character of the relief, although any child could ascertain its amount. So far as it goes, the information such a map gives is clear and definite; and it is doubtless on this account that contours have largely superseded hachures as a means of showing relief on maps. Shading by hachures is now so little used that it may be said, in a general way, that maps made on that system indicate principally a lack of data. When a map-maker does not know whether a certain mountain chain is 1,000 or 10,000 feet high, or whether it is ten miles or a hundred miles long, and has no idea whatever of its width, he naturally prefers to indicate it by a few pen lines, which might mean one or the other of these things. The contour method is essentially a system of quantity of relief, and succeeds in showing that, but at the expense of quality or character.

On contoured maps made on a large scale, with contours of small interval, the lines have some graphic value, as when placed closely together they produce a kind of shading, but usually they serve to show only the relative relief. In a general way it may be said that the hachured system is a qualitative one with a quantitative element, while the contoured system is a quantitative one with a qualitative element. Relief maps are more graphic than hachures, and surpass contours in showing the relative elevations.

For engineering work, and for many other technical uses where quantity of relief is the main desideratum, contoured maps fill the requirements and are superior to any other. But for general use the system falls far short of being perfect. Similarly, where quality of relief is more important than quantity—as, for example, for the use of the army—hachured maps are more serviceable. The most ambitious work of this character in this country was the War Department survey of the region west of the 100th meridian, designed primarily for the use of the army. That work was discontinued some twenty years ago, and was never resumed, as the present Geological Survey, using the contoured system, replaced it.

In the element of clearness—not the least essential in maps—contoured work has a very decided advantage, since the relief is shown without obscuring other details, such as lettering, drainage, culture, etc. Indeed, in this respect it is much superior to relief maps, the graphic qualities of which are much lessened by the addition of other data. Still, if the model is made with reference to the use to which it is to be put, this disadvantage can be overcome to a large extent, if one bears in mind that strong lines of any kind, other than drainage, have a tendency to destroy relative relief.

Modelling as a method of showing relief should be considered as an elaboration rather than as a rival of the other methods, for in the making of a relief map the first essential is a good hachured or contoured map. The principal use of models must be, therefore, in those cases where the best results are desired, irrespective of comparative cost. Relief maps require a large amount of minute and painstaking labor, of the highly skilled variety, and are, therefore, expensive. The cost per square foot covers a wide range—from $5 to $50—and, to a large extent, is under control, for it depends principally on the character of the work, the purpose for which it is done, and the degree of accuracy which is demanded. A sketch model of a large area on a small scale does not require one-tenth of the time and labor demanded by a relief map of the same area made closely to scale and of the highest degree of accuracy; that is to say, as accurate as the map from which it is made. On such models a day's work might not be more than a section measuring two by three inches, requiring three weeks to the square foot; while in a sketch map, where the permissible error is large, the workman could average over a square foot each day.

Aside from manual skill the prime requisites in the equipment of a good modeller are a thorough knowledge of topographic form, a wide familiarity with maps and the ability to read them, and a specific knowledge of the region to be modelled; or, failing that, he must possess at least a clear conception of what he seeks to show. Perhaps the best training for a modeller is the actual work of surveying in the field, and the drawing of maps from the instrumental data thus secured. It is hardly reasonable to expect good modelling work from a person who has never seen a mountain chain, and whose knowledge of maps is limited to what can be learned from the printed product; yet many relief maps have been made by such persons. It is not surprising, therefore, that topographic models are not always satisfactory.

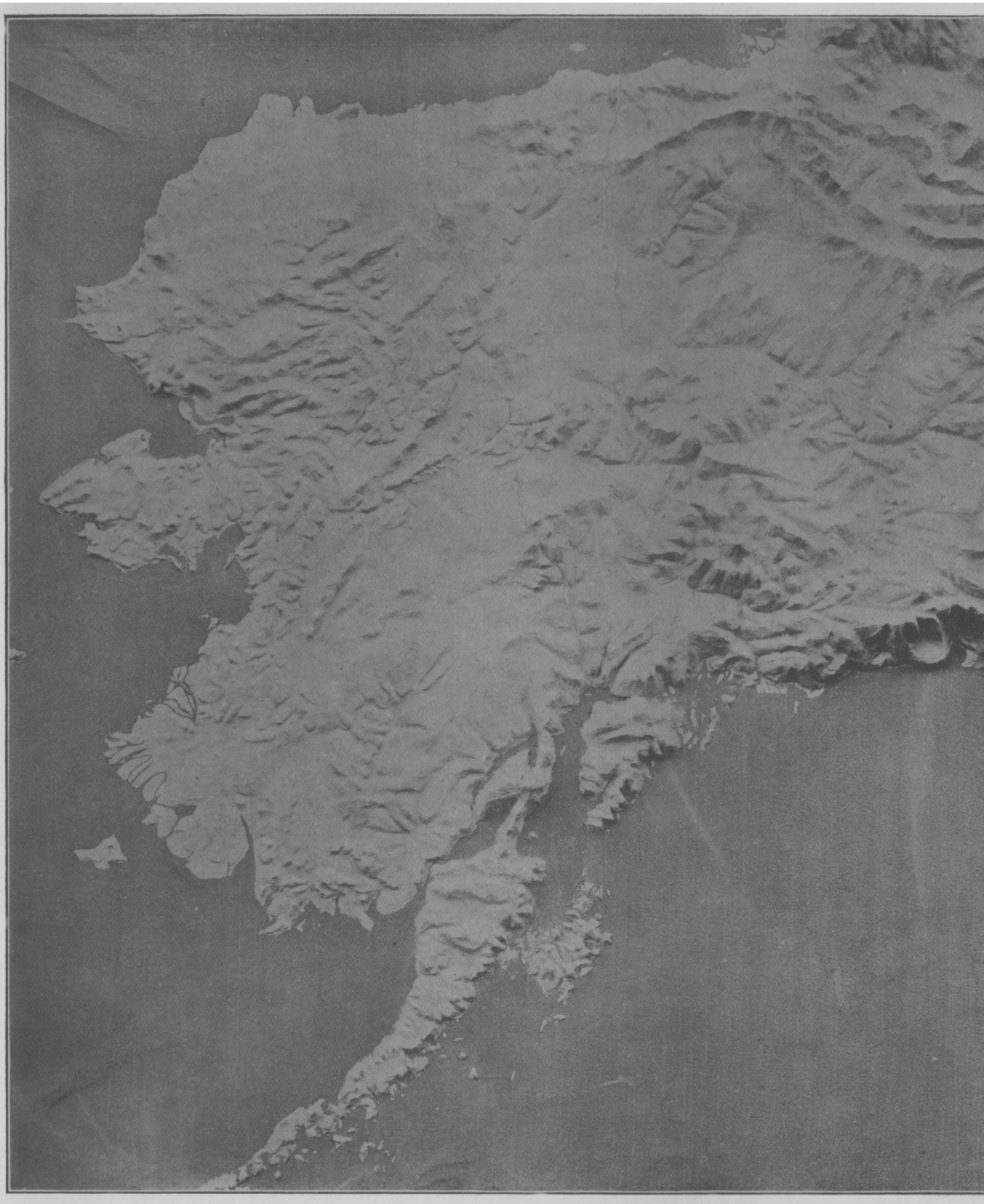
The modeller must be an artist as well as a topographer—which is, by the way, rather a rare combination. He must not only know topographic forms, but must have a feeling for them and the ability to give expression to that feeling in a material medium. Theoretically, the topographer without artistic feeling should be able to make a better relief map than the artist without topographic knowledge, for he would know at least what he wanted to do. Practically, however, the artist succeeds better than the topographer, for his trained imagination partly supplies what he lacks, and enables him to form a mental picture of the whole, which it is not difficult for him to incorporate in clay or wax; while in the surveyor's mind there is nothing but an aggregate of detail. Artists differ widely, however, and in many instances it is a case of "all maps look alike to me."

Given an expert modeller and a good contoured map, the procedure of relief map-making is simple. If all the topographic data on the map are to be used, as many copies are made as there are contours: if the maximum elevation is 1,000 feet, for example, and the interval is 100 feet, there would be ten copies. Upon a baseboard representing sea-level, or some other assumed base, one of the maps is mounted, and the others are pasted upon thin wood or cardboard of the exact thickness required by the vertical interval; in the example cited, with a vertical scale of 1,000 feet to an inch, each contour would be one-tenth of an inch. Each cardboard is then placed under a scroll saw, which follows the contour line, all that portion below that level being rejected. Thus the first contour sawed out shows nothing below the 100-foot level but everything above it, including the 200-foot line; the second contour shows nothing below the 200-foot level; and so on. It is then a simple matter to tack the second contour on the first, since its edge is the same as the 200-foot line, and to continue the process until all the raised contours are in place. At this stage the model should be an exact copy of the contoured map, but with the contours in relief, rising in a series of steps or terraces from sea-level, or the base, to the highest mountain summit. In some instances the model is not carried beyond this stage, but usually this is merely the base upon which the modelling is done.

Up to this point the work is mechanical and can be done by any ordinarily careful person; no knowledge of topography nor skill is required. In the next step, however, these qualities come prominently to the front. Upon the raised contours as a base the modeller fills in the topography with clay or wax, or whatever medium he employs, converting the conventional map into a lifelike representation of the country. Ordinarily he has no other data than the map upon which he works; but if he is competent that is sufficient. Every minute variation in the trend of a contour line and every change in its relations to the lines below and above it mean something; the modeller knows exactly what that meaning is and is able to incorporate it in the wax. He cannot go far wrong, for the contour interval is small—often, indeed, minute; ordinarily less than one-fifth of an inch, and often not more than one-fiftieth.

In other words, to the modeller the raised contoured map is merely a means of control, occupying much the same relation to the finished work that the primary and secondary triangulation do to the map. To fill in the raised contours by connecting their edges by slopes, and calling the result a relief map, is almost as senseless as it would be to fill in the region between the primary triangulation points on the map with straight lines; yet it is often done. The modeller should be able to look through the map and see what the surveyor saw; he must undo the generalizing that was done, and supply the detail which is necessarily omitted in the map or so slightly indicated that it is apparent only on close study. Unless he does this the relief map he makes will be "wooden" and lifeless, and will not be a true representation of the country.

Where the object sought is a graphic representation of a region, accuracy of detail, while important, is not so essential as that broader truthfulness which shows the country as it is, or rather as it appears to be. The point can be illustrated by a reference to the celebrated Muybridge series of photographs of moving animals, which made a sensation many years ago when they were brought out. It was shown, for example, that all the drawings ever made of horses galloping were entirely erroneous; that at no time in the



RELIEF MAP OF ALASKA.

RELIEF MAP OF ALASKA.

movement did the horse's feet take the positions shown in the drawings. Thereupon some artists adopted the facts thus determined, using them in their work; but the result was so grotesque that the plan was soon abandoned for a return to the old methods, which showed galloping horses as they appeared and not as they are. Similarly, the difference between a good model and a bad one is the difference between a portrait and a photograph—one shows character, the other exhibits only detail. Where detail is the main desideratum the problem is not so difficult.

When the model is to be reproduced by photography, however, the graphic feature is the dominating element, and the enormous reduction which the model suffers is more than sufficient, usually, to eliminate the result of any liberties that may have been taken with the scale. With a contour interval of one-twentieth of an inch—which is larger than ordinary—only a very careless modeller would run off his scale as much as a contour and a half, even in a sketch model. This would mean about one-fifteenth of an inch on the model, or less than one-fiftieth of an inch on the photograph, with the ordinary reduction; less, usually, than the permissible error on the original map from which the model was made. It will be seen, therefore, that the question of accuracy of detail has been given an undue prominence, and, unfortunately, at the cost of truthful representation in its broader terms. It is so much easier to make an accurate model than to make a relief map that is really a portrait that the former is much more common than the latter.

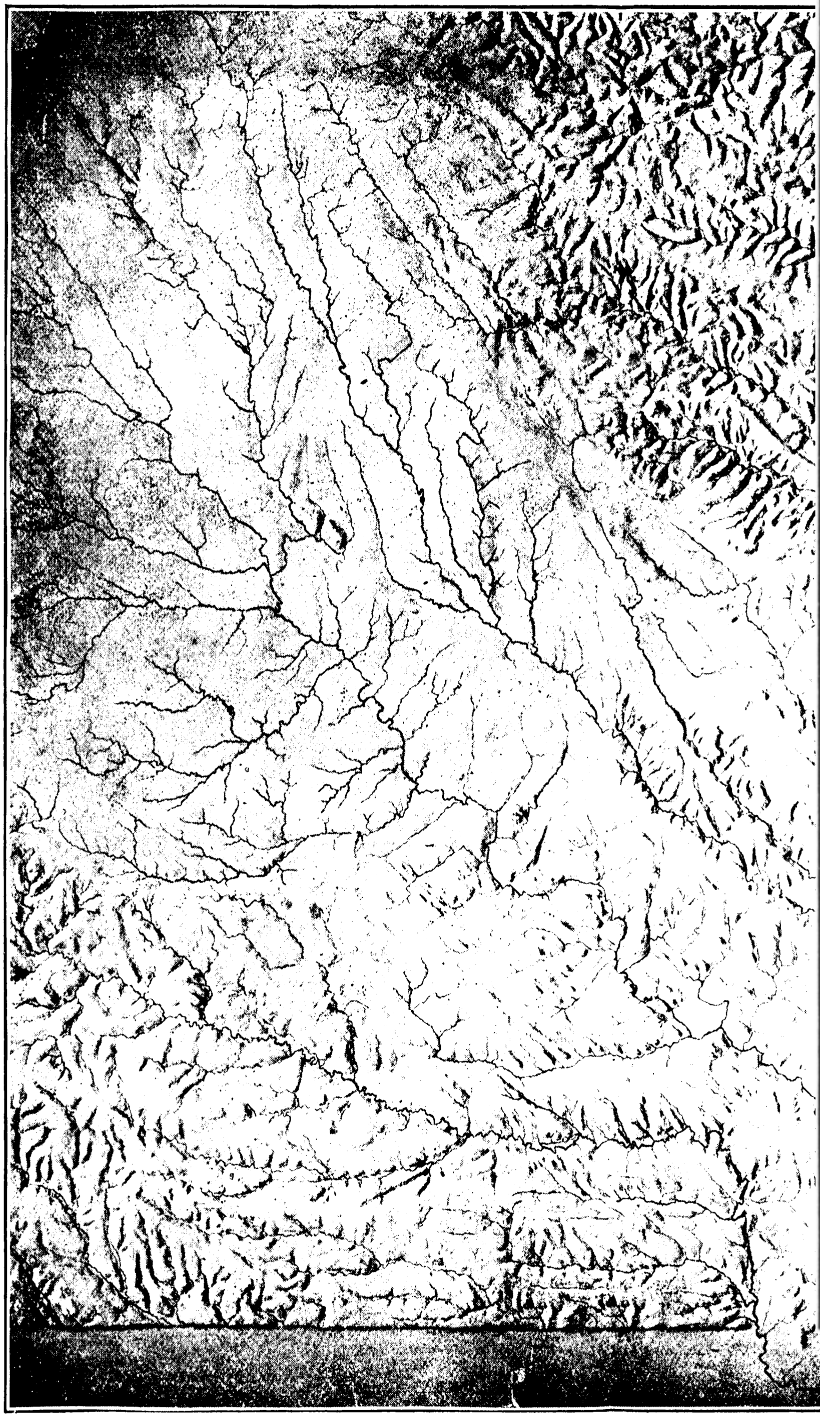
Another problem closely related to the foregoing is the amount of exaggeration to be given the vertical scale—and on its proper determination depends, to a large degree, the success or failure of the work. Theoretically, a truthful model would have no exaggeration; practically, in very many cases, such a model would show so little that it would be worthless. Unfortunately, the matter of relative vertical scale has been the subject of bitter controversy—principally among scientific men, not among modellers. The latter should know best what is required, and the determination should be left to them, if they are competent. In a general way the scientific man advocates too little exaggeration and the modeller too much.

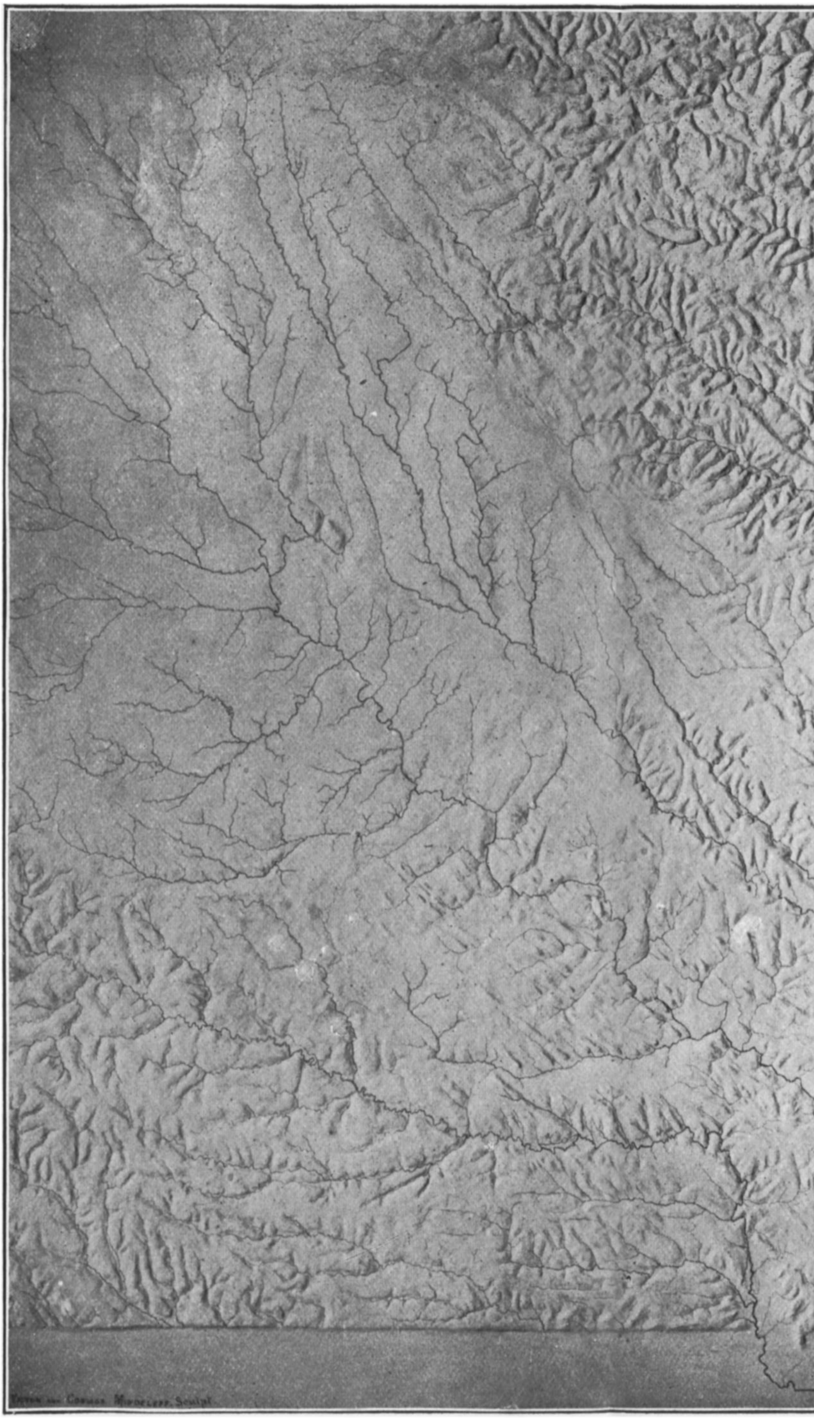
One well-known chief of a State survey went to the extent of declaring some years ago that, "He that will exaggerate the vertical scale of anything will lie." On the other hand, it is obvious that he who attempts to make a small-scale model of a large area without vertical exaggeration lacks sense. A relief map of the United States, for example, 30 inches long, would have a vertical scale of over 500,000 feet to an inch; the maximum relief would be about one-thirtieth of an inch, and the general relief in the mountainous districts less than one-fiftieth. In other words, for all practical purposes, there would be no relief at all; the result would not be a relief map. Models have been made, however, in which the mountain peaks looked like church steeples, and a chain of them had the appearance of the teeth of a saw.

One of the principal effects, or defects, of vertical exaggeration is to diminish the apparent size of the region shown. As the relative height of the mountains is increased, the comparative width of the valleys is necessarily diminished. Few persons would realize from a study of a relief map of California, or of any other kind of map, that to the traveller the great valley of that State presents much the same appearance as the plains of Kansas; yet with a proper selection of scales that effect can be suggested in a relief map, if not actually shown.

Where the result desired is a pictorial one—that is, where a graphic representation of the country is wanted—it is the absolute and not the proportionate relief which is important. Whether the horizontal and vertical scales are as 1 to 2, or as 1 to 20, is immaterial. In the sketch map of South America, made for reproduction by photo-engraving in a much-reduced scale, the vertical exaggeration is 25. That would be absurd if applied to other subjects made for other purposes, but in this case the result was satisfactory. On the model itself, which measured about three feet in length, the absolute relief was about three-quarters of an inch, although it looked to be double that. In a general way that amount—from one-half to three-quarters of an inch—may be taken as the proper amount of relief for a model of that character, although in some cases it can be made smaller with advantage.

As an illustration of the scanty knowledge on this subject which is possessed by men who are ordinarily well informed, reference may be made to a bill introduced a few years ago in Congress, providing for the construction of a huge relief map of the United States on one of the public reservations in Washington, close to the Washington Monument. The measure provided for a scale of a square yard to a square mile, which would make three feet to a mile. The amount of ground surface to be modelled would be over 51,000,000 square feet, which, even at 10 cents a foot, instead of $30, which is a fair average price, would cost $5,000,000. The model would be over a mile and a half long and over a mile wide. Without vertical exaggeration, the highest mountains would rise





RELIEF MAP OF NORTH EASTERN IOWA.

about nine feet above the base, while in the eastern part of the model the greatest height would be less than three feet. That amount would be hardly perceptible in a subject a mile and a half long, although, theoretically, in a model of such large scale no vertical exaggeration should be necessary.

Models of large areas are sometimes made on a curved base, representing a section of the earth's surface. This would doubtless be regarded as essential in such a model as that proposed. The actual curvature of that section of the earth covered by the United States is about 480 miles. Were the proposed model made without vertical exaggeration it would have to be bulged, or rise from the flat, on the scale proposed, 1,440 feet—almost three times the height of the Washington Monument, near-by. With such vertical exaggeration as would be necessary to bring out the relief, the curvature of the model would be very much greater. As a matter of fact, a model 100 feet in diameter would express much more than the vast work proposed, and its cost would be only a minute fraction.

The ability or skill of the modeller is an important element. A good workman can show relief and character in much less space than a poor one finds necessary. A vertical scale of 40,000 feet to an inch, allowing one-fortieth of an inch to each contour interval of 1,000 feet, seems very small, yet it is sufficient to bring out the main features in a small-scale model of a large area. One-fiftieth of an inch can be shown readily, and where the features are well marked, one-sixtieth. On the other hand, in a large-scale model of a region in which the topographic features are not strongly marked—a rolling country, for example—a difference of one-twentieth of an inch is hardly perceptible. It is impossible, therefore, to make any general rule as to the proportion of scales, or even as to the absolute relief required to secure the best result. Each case must be considered and decided by itself.

After the surface of the relief map has been modelled in wax or other material, the further steps in the process depend on the purpose of the work. If designed for photographic reproduction, all that is necessary is to paint the model white, with the drainage and water surfaces in blue. This can be done as well on the wax surface as on a plaster reproduction; and the effect is more satisfactory, for in moulding and casting some of the fine detail is necessarily lost. Indeed, the slight roughness of the wax surface which comes from tooling adds materially to the effect and should be preserved if possible; while the clean, sharp edges of the original work, which add much to its expressiveness, can be retained only by making the photograph from the wax. The original model, if properly made, is, for all practical purposes, as permanent as a plaster cast, and where only one copy is wanted, is in every respect preferable.

The photographing of models is an art in itself, and many professional photographers fail to secure good results through inability to manipulate the lighting properly. A white-painted model is extremely sensitive to slight changes in the amount and direction of the light, and small variations in these elements make pronounced differences, not only in the general appearance of the model, but also in the amount of the relief shown. In a general way the more oblique the light the more pronounced the relief; yet if the angle be made too small all the detail in the heavy shadows will be lost. This difficulty can be obviated by the use of reflecting screens to light the shadows, as is done in portrait photography. Only by numerous experiments can the best conditions be determined, and those conditions necessarily vary with each subject.

The preparation of the model for photographing is an important preliminary, which has not always received the attention it should have. If the surface is glossy there will be numerous local reflections which will "kill" the relief as effectually as bad lighting; the best finish is that known among painters as an egg-shell gloss. Furthermore, while the model should be white, it should not be a pure white, since in that case the contrast between the high lights and the deep shadows in the photograph is too pronounced. A very slight tinge of yellow—so slight as to be imperceptible to the eye unless compared with a white surface—gives the best result. But these problems are technical ones; enough has been said to show that skill and experience are as necessary in making the photograph as in the earlier stages of the work. The point which it is sought to illustrate is, that with skill and care better results can be secured with relief maps than in any other way, but that competence, knowledge, and attention to detail are essential to success.

As no satisfactory method of duplicating relief maps at small cost has yet been developed, the only available means of reproducing such work that is practicable is by photographic processes. A model, the first cost of which is perhaps $500, and duplicates of which could hardly be made for less than $100 each, could be reproduced by photo-engraving, and if the edition is large enough the maps could be sold at a profit at five cents each. As such relief maps are immensely superior for many purposes to other kinds of maps which cost more to print than the amount stated, since they are usually in two or three colors, there is no apparent reason why photo-engravings of models should not in time supplant the other methods for many purposes. One thing that has militated against such development is that most of the work done so far has been by amateurs. Should the demand become large enough a class of specialists would be developed, and much better results could be looked for. That such demand will arise eventually seems probable, since there is a consensus of opinion among scientific men and laymen as to the value of relief maps, and none of the difficulties in the way of good results is such that it cannot be overcome by skill and knowledge. One relief map should not be expected to serve two or three conflicting purposes, but the work should be done with especial reference to the end sought, and to that end only. Methods should be subordinated and more attention given to the finished product. In certain classes of scientific work, where the method employed is important, the modeller could be required to state his procedure, as the chemist does. But relief maps should be regarded as artistic and not as scientific products.

It must not be inferred from the absence of descriptions in this article of methods of constructing relief maps, other than by sawing out and building up the contours, that the method given is the only one. On the contrary, their name is legion, and indeed every new piece of work presents problems of its own which must be solved as it progresses. Several pages might be devoted to descriptions of different ways in which models have been made, but the question is purely a technical one. The three relief maps used to illustrate this article were made by three different methods. In the case of South America, concerning which general data are fairly good but detailed geographic information is lacking, contours of various interval were used in the base and the modelling was done with a free hand, with especial reference to a photographic reduction from three feet to less than ten inches. In the map of Alaska, where data are very scanty, the map was mounted on a base board, pins were driven at all points where elevations are known, mostly mountain peaks, and all the intervening region was filled in from the hachured map, most of the information on which was derived from description. In the model of northeastern Iowa the topography, which is of an entirely different character from both of the preceding, was modelled over a carefully made contoured base, and was finished under the personal inspection of a geologist who was familiar with almost every foot of the ground. The scale also was much larger and the vertical exaggeration less. This model is much more accurate than the other two, but is not so expressive—partly, perhaps, because the region depicted is a rolling or hilly country and not a mountainous one.